## Slide 1

Including the Effects of Appraisal and Caffeine in the ACT-R Cognitive Architecture

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Applied to a Serial Subraction Model
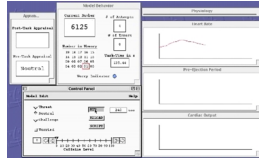
Workshop on ACT-R Models of Human-System Interaction

Slide 2

Argh! / OK

$3674 - 7 = X$

NEW IDEAS

- Overlay for ACT-R Architecture
  - Hidden physiology variables influence cognition
  - Based on cog. architecture
  - Worry as dual-task
- Biopsychology data to validate models
- Clear displays of behaviors

IMPACT

- Cognitive models migrate to biopsychology
- Approach can include further moderators
  - caffeine, nicotine
  - fatigue
  - moderator interactions
- Overlay applies to all ACT-R models

Does subtraction with overlay   Caffeine and interactions, model and fit   More interactions

5   7   12   24   36

YD model with overlay   Vigilance task More stimulants

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Slide 3

Motivation

- Modeling cognition and affect including stress (multiple behavioral moderators that influence architecture processing)
- Important for modeling aspects of human-computer interactions
- Extending computer-generated forces

Slide 4

Our Approach

- Cognitive architecture (ACT-R)
- Biopsychology models and data
- Validation of model's behavior
- Displays to explain model to
  analysts
  readers

Slide 5

Data to Be Modeled: Challenge Appraisals

- Pre-task appraisal and Caffeine
  - Ł Important effects in humans

- "Challenge" pre-task appraisal:
  - ›› heart rate, ›› sympathetic arousal, vascular dilation: good energy mobilization (fight-or-flight)
  - › subtraction attemps
  - › percent correct responses

Slide 6

Data to Be Modeled: Threatening Appraisals

- "Threatening" pre-task appraisal
  - › heart rate, › sympathetic arousal, vascular constriction, poor energy mobilization
  - fl subtraction attempts
  - fl percent correct responses
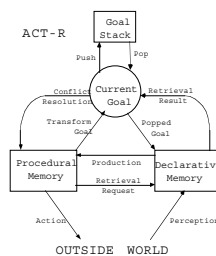- Why? We will propose a model why

Data to Be Modeled: Caffeine

- Qualitative performance: an inverted U-shaped curve:
  - Low and high levels of caffeine --> poor performance
  - Moderate levels of caffeine --> optimal performance
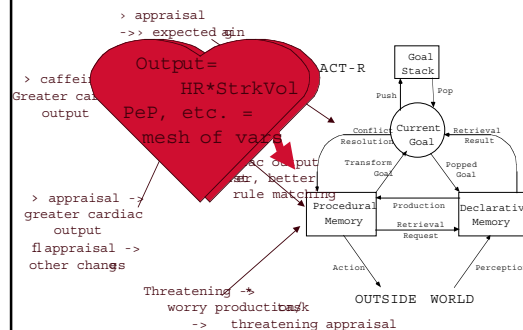- Quantitative measures with this task needed from future study

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Subtraction data: Neutral and Non-neutral Appraisal

- We have RTs from the literature
- Problem is that we will need more detailed data with moderators active
  - Typically, with moderators active only gross performance measures are taken

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ACT-R 4.0

ACT-R

Goal Stack

Push   Pop

Conflict Resolution   Current Goal   Retrieval Result

Transform Goal   Popped Goal

Procedural Memory   Production   Declarative Memory
Retrieval Request

Action   Perception

OUTSIDE WORLD

ACT-R / A / C

> appraisal -> expected gain

Output = HR*StrkVol

PeP, etc. = mesh of vars

> caffeine Greater cardiac output

> appraisal -> greater cardiac output

fl appraisal -> other changes

Threatening -> worry production -> threatening appraisal

ACT-R

Goal Stack

Push   Pop

Conflict Resolution   Current Goal   Retrieval Result

Transform Goal   Popped Goal

Procedural Memory   Production   Declarative Memory
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OUTSIDE WORLD

AC T-R Model of Subtraction

- Create goal to serial subtract
  - Subgoal to do current column
    - Two strategies: count-down and subtract
    - Get column answer
  - Repeat across columns
  - Report result
- 28 rules
- 15 state chunks + 230 math facts (~250 total)

|	Effect	Implementation
Pre-task appraisal	Challenge leads to more attempts, less errors	Increase Goal value
		Increase working memory
		Decrease Expected Gain Noise
		Increase circulation, generally
	Threat leads to fewer attempts, more errors	Decrease goal value
		Decrease working memory
		Increase Expected Gain Noise
		Complex changes in circulatory system
Caffeine	Increased alertness with inverted U-shaped curve	Affects threshold at end of 4 min. run for Challenging post-task appraisal
	At moderate doses decreased RT	Indirect through task appraisal
	Exacerbate the effects of anxiety	Decrease errors needed for post-task appraisal being "threat"

The Subtraction Model doing subtraction
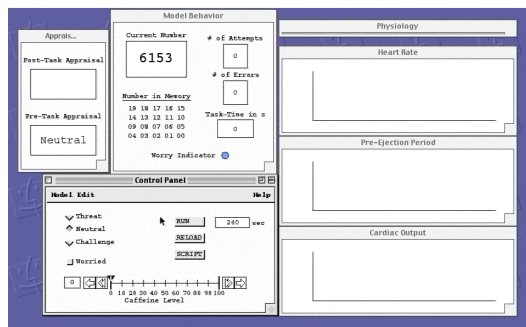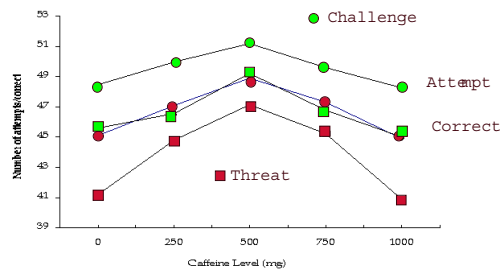

Subtraction Model with Threat
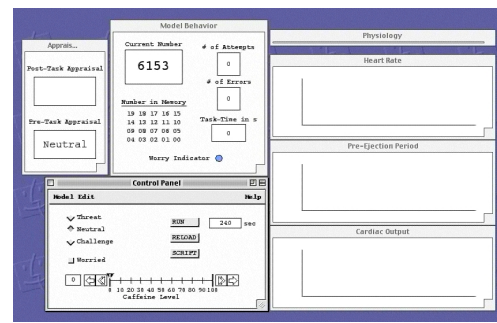
# Effects to Simulated Heart
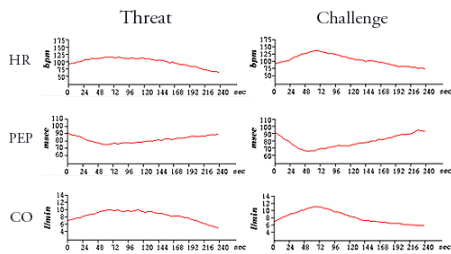
Answers: Predicted and Actual

Pretask appraisal :		Challenge		Threat		Neutral
Simulation	Attempts	50	>	41.2	<	47.3
(N=10)	Number correct	48.4	>	37.8	<	44.8
Simulation with Worry	Attempts	39.2	>	32.5	<	35.8.
(N=10)	Number correct	37	>	29.5	<	33.2
Tomaka et al. (1993)	Attempts	61	>	46		n.a.
	Number correct	56	>	42		n.a.

Effects of Caffeine

*Output of Model in ACT-R/A/C

Output with appraisal1 Output with appraisal2 Output with Caffeine and appraisal
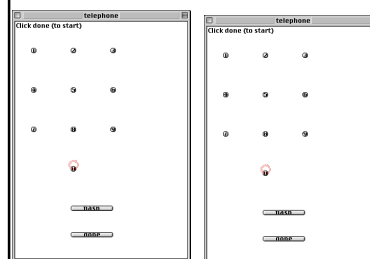
[Future Work]

Summary of Subtraction Model with /A/C Overlay

- Qualitatively matches published human data
- Continued development possible
- Overlay can be applied to a wider range of tasks, e.g., Yerkes-Dodson task and model, driving, telephone

Summary of Development

- Work started March-August 2001
- Weekly meetings through semester led to data and task selection
- Initial subtraction model built in one week, revisions weekly

Accomplishments

- Currently main effect of appraisal
  - Can include effects of pre-task appraisal and caffeine
- Partial match to data now
  - Match to limit of data
- A cognitive architecture overlay, allows theory reuse

Distributed Code

- acs.ist.psu.edu/serial-sub
- Overlay, model, worry dual-task, interfaces, traces, picture
- Leaves out internal, physiology variables

Next Steps

- Paper submitted to *IJHCS*
- Overlay can be applied to Belavkin's YD model, dialing
- Measure and fit caffeine interaction effects more directly measured
- Find further regularities, further stressors

Open Questions

- ACT-R's model library is not yet large enough to cover tasks (about 1/4 of published 'available')
- How to have more data in hand for modeling?
- How to overlay multiple overlays?
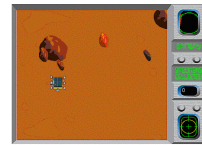- How to create displays faster and so that they work together?

Thank You

The Interfaces We Are Examining

- More autonomous
- More high level
- More like the future

- Less autonomous
- More like today
- Lower level
- Will still be used even in the future

Where Next ?

- Eye/hand connected
  Works under Windows with tasks
  - Based on pixels, so transportable
  - Colors, positions, sizes
  - Outputs for hands
  Moving to Unix
- Start to model tasks

ritter.ist.psu.edu/papers/ritter-papers.html